Biochronology of shell rings in freshwater mussels

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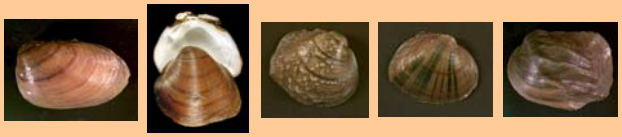
Some background:



- Virtually all bivalve shells have concentric rings similar to tree rings
- Shell rings have been noted for many years (Leonardo da Vinci noticed them), BUT,
- The assumption of annual formation of rings has been validated only recently in freshwater mussels

Validation of their annual periodicity unlocks a wealth of information contained in shell rings. As for trees, fishes, and many other organisms, age and growth information can be extracted from these rings. Further, because some mussels can live to > 100 years, these rings represent a long-term record of growth and interaction with the aquatic environment.

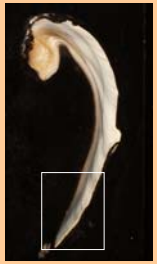
Shell rings tell us that growth rates and longevity differ greatly among mussel species. In the case at left, size can be deceiving.

Although rings on the external shell surface are often useful, interior rings examined microscopically in cross-section offer the most unambiguous view of annual rings.

(Above) Shell erosion can obscure external shell rings

(Above) Plane of initial cut for cross-section

(Below) Mussel shell cross-section (~300 microns thick). Rectangle outlines section of shell shown in subsequent micrographs.

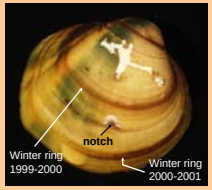


(Above) Microscopic examination of cross-sections allows resolution of even tightly crowded shell rings in older specimens with slow growth (specimen above 37 years old, Southern hickorynut, *Obovaria unicolor*).

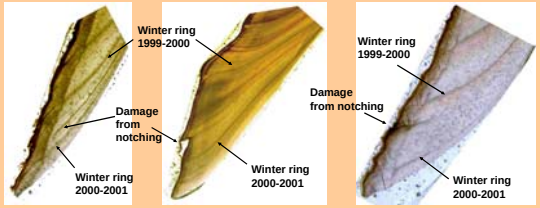
Some recent research:

With Amy Commens (Biological Technician at Oxford) I demonstrated annual deposition of shell rings in 17 mussel species from 3 rivers and in 3 years. Rings are formed during cessation of growth in winter.

(Above) Shell notched with a file in summer 2000 and collected in fall 2000 near end of growing season. Note absence of winter ring after notch. (Pimpleback, *Quadrula pustulosa*)



(Above) Shell notched in summer 2000 and collected one year later (summer 2001). Note presence of a single winter ring after notch. (Pimpleback, *Quadrula pustulosa*)



(Above) Cross-section of shells notched in summer 2000 and collected one year later (summer 2001), showing deposition of a single winter shell ring per year. (left, Alabama orb, *Quadrula asperata*; middle and right, three-horned wartyback, *Obliquaria reflexa*)

Mussels also deposit conspicuous rings in response to disturbance. Even gentle handling (without filing notches in shells) results in a disturbance ring or even minor shell damage. Disturbance rings are distinguishable from annual rings using a suite of qualitative characters. Disturbance rings are also seen frequently in shells not handled previously, indicating that disturbance is common in nature.

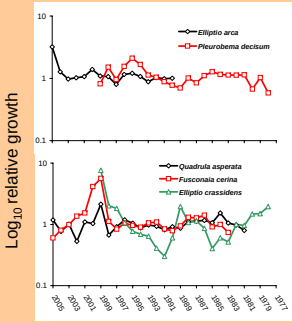
(Above and right) Cross-sections of shells tagged in summer 2003 and collected one year later (summer 2004), showing shell damage caused by handling (arrows). (left, mapleleaf, *Quadrula quadrula*; middle, fragile papershell, *Leptodea fragilis*)

(Above) Shell tagged in summer 2003 and collected one year later (summer 2004), showing disturbance ring caused by handling (arrow). (pimpleback, *Quadrula pustulosa*)

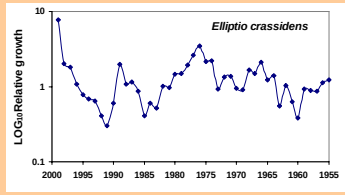
Some current research:

Using information recorded in shell rings, we are able to examine the history of growth and disturbance over a period of many years. Recent results show that mussels are sensitive to a variety of environmental factors but some species respond differently to these factors (see graphs below). Some other results:

- Growth is negatively correlated with a number of hydrologic variables including autumn and winter streamflows, seasonal timing of flood pulses, and to climatic variables including the El Nino Southern Oscillation, the Atlantic Oscillation (AO), and the annual number of hurricanes.
- The occurrence of natural disturbance rings in mussel shells is also correlated with the timing of flood pulses and hurricanes



(Above) Two groups of mussel species with distinctive long-term patterns of growth. Within groups, annual growth is significantly correlated among species.



(Above) A long-term growth chronology showing predictable oscillations in growth occurring on about a 10-year cycle.

We are also comparing growth patterns of mussels with other organisms in these ecosystems including several species of fishes and Baldcypress, but as yet have few results from this component of the research.

Some ideas for collaboration:

We are excited about the potential for using shell rings to study historical and recent changes in the aquatic environment and are eager to apply this approach in a variety of settings through collaboration with other researchers. Here are some of my ideas:

- Building chronologies for mussels in other areas, especially
  1. areas that have a documented history of disturbance (e.g., fire, hurricanes)
  2. areas that have or will receive some kind of management treatment
- Comparing mussel growth chronologies with other organisms in the ecosystem

Let's hear your ideas….